Effect of cultivation measures on economic benefit of *Larix olgesis* pulp forest

LI Feng-shan
(Northeast Forestry University, Harbin 150040, P. R. China)

Abstract: According to the cultivating practice of *Larix olgensis* pulp plantation, IRR (Internal revenue rate) and NPV (Net present value) were taken as two economic indices to study the effect of cultivation measurements on economic benefit of *Larix olgensis* pulp forest. The results showed that the economic benefit of this type of forest is closely related to rotation and site class. Higher economic benefit could be obtained when the rotation is shorter and site class is higher. The planting density also had an obvious influence on economic benefit. On the base of assuring survival rate and conserving rate, the less the fee used in soil preparation and young growth tending is, the higher the economic benefit is. The influence of determined six cultivation measures on economic benefit in sequence was the rotation—site class—density—management fee level—young growth tending intensity— soil preparation methods.

Key words: Cultivation measures; Economic benefit; *Larix olgensis* pulp forest.
CLC number: S795.4; S791.22.06 **Document code:** A **Article ID:** 1007-662X(2001)03-0179-04

Introduction

As a form of expression of wood cultivation that industrial fiber plantation reflects good production, must deal with economic benefit. It is an effective way for reducing the cost of industrial fiber plantation cultivation and raising economic benefit to deeply study economic benefit affected by cultivation measures. Now many countries have taken economic study method as an important basis to choose and determine cultivation measures of industrial fiber plantation (Grado 1989; Lothner 1983, 1986; Sedjo 1984; tarler 1991; Wang et al. 1998). *Larix olgensis* is a mainly fast growth planting species in Northeast forestry region of China. It is widely applied because of its fast growth, broad distribution, high feasibility and good wood property. Cultivation of *Larix olgensis* plantation was chosen into state plan between 1980 and 2000. A great deal of achievements has been achieved, but there are few reports on economic analysis of cultivation measures (Wang et al. 1992, 1996, 1997, 1998). In this paper, we clarified the effect of cultivation measures on economic benefit according to the cultivation practice of *Larix olgensis* pulp plantation and aim at providing a scientific bases for the cultivation of *Larix olgensis* pulp plantation.

Study methods

The study area was Heilongjiang Province part of II production region in divisions of *Larix olgensis* high-yield plantation producing area (the Forestry Ministry of P. R. China, 1986). Forest managing cost of Heilongjiang State Farm Bureau was chosen as investment basis (Table 1).

Thinning cutting cost was calculated from formula Y=149.6172+19.9155X, where X stands for age, Y stands for cost, R=0.99. Main cutting cost was 1 095 yuan per hectare that express average main cutting cost of Heilongjiang Province.

For output value analysis, a harvest table was compiled based on stand structure and growth process. Diameter distribution and calculating height of different diameter were checked out, and the quantity of different standard wood was calculated (He 1990). Finally, the output value was calculated bases on the value of different standard wood. 360, 335, 300, 270 and 255 yuan per cube meter is for diameter more than 18 cm, 16 cm, from 12 cm to 14 cm, from 8 cm to 10 cm, and from 4 cm to 6 cm, respectively.

Analyzing cash discharge during cultivation period, we can set up cash discharge table. The financial indices are net present value (NPV) and internal revenue rate (IRR). NPV is an important index expressing cultivation model. And then NPV is the difference between total input value and total output value. IRR is the discount rate when cash input value equals cash output value and NPV equals zero.

Results

Site class and IRR

As a result of different site class, the IRR of *Larix olgensis* pulp plantation have significant difference. The higher the site class is, the higher the IRR is. The IRR of site class I in different rotation changes from 11.62% to 27.2%. And the IRR of site class II in different rotation decreases from 10.63% to 22.72%. The IRR change of various site classes

Foundation item: This paper was supported Sciences and Technology Office of Heilongjiang Province (G99B5-10).
Biography: LI Feng-shan (1964-), female, accountant in Northeast Forestry University, Harbin 150040, P. R. China.
Received date: 2001-04-10
Responsible editor: Song Funan

is also obvious because of the difference of the initial density and rotation. The shorter the rotation is, the bigger the difference of IRR among site class is. During the same rotation, the difference of IRR vary with initial density. The bigger the initial density is, the smaller the IRR difference of different site class is. The IRR differences of different initial densities based on the difference of site class were from 3.12% to 5.23% for 15-year rotation, 1.59% to 1.89% for 20-year and 0.99% to 1.31% for 40-year, respectively. From above relationship between site class and IRR, only when the rotation is shorter than 30 years or 25 years shorter, the IRR of site class I and site class II can be more than 15%. From the change of IRR, *Larix olgensis* is suitable to be cultivated on site class I and site class II with low initial density and short rotation (Table 2).

Relationships between afforestation density and IRR

The IRR decrease with afforestation density increasing except on site class II that the rotation is 15 years and density is 2 000 individuals per hectare. On site class I, the IRR difference caused by density is 3.46% at 15 years, 2.75% at 20 years, 2% at 25 years, 1.51% at 30 years, 1.25% at 35 years, and 1.04% at 40 years, respectively. On site class II, corresponding IRR difference to the site class I is 2.10%, 2.455, 1.68%, 1.23%, 0.95%, and 0.72%, respectively. With site class decreasing, the IRR difference caused by density become smaller and smaller. On the same site class, the longer the rotation is, the lesser the IRR difference caused by density is. The change of IRR caused by density expresses a management program with high site class and short rotation (Table 2), and comes from thinning cut profit. For calculating thinning cut profit, the thinning method is determined as low layer tending cutting. When the stand age exceeds 15 or 20 years old, the initial density cannot affect the IRR. The initial density only can affect thinning cutting of the first time or second time. If the initial density is bigger, the thinning wood standard will be lower, with less wood output, and profit will be less or even zero. With the rotation getting longer, the density effect on IRR become less, and when the rotation is longer than 30 years, IRR changes only within 1%~2%.

Relationships between rotation and IRR

Confirmation of the rotation mainly depended on the mature of quantity, technology, and economics. IRR decrease gradually with the rotation prolonging. The rotation causes IRR extremely different, from minimum 9.99% to maximum 14.54%. IRR is the biggest in 15-year rotation and the smallest in 40-year rotations. The IRR difference for the rotation of 15 years and 40 years on site grade I is bigger than those on site grade II. All these further illustrate the fact that high site grade is suitable for short rotation cultivation, low site grade need to prolong cultivating period (Table 2).

Table 1. Forest management cost table(Yuan / hm^2)

Planting density (tree/hm^2)	Preparation	Seedling	Soil preparation	Planting	Replant	Young growth tending	Light passing	Forest protection	Management	Other	Spring soil preparation
4400	130.05	145.50	385.05	140.25	39.90	360.15	341.70	1292.55	827.40	318.00	238.35
3300	130.05	109.20	306.30	113.25	34.80	302.85	278.40	1292.55	827.40	318.00	219.30
2500	130.05	82.80	249.00	93.60	30.00	261.15	278.40	1292.55	827.40	318.00	204.60
2000	130.05	66.15	185.70	68.70	27.00	183.60	278.40	1292.55	827.40	318.00	151.50

Note: the data in the table is based on planting density. Management period of forest protection, management and other fee is forty years. The light passing tending of young growth is carried out at age of 10. The afforestation fee of different density is reduced according to certain proportion.

Relationships between soil preparation methods, young growth tending method, management fee and IRR

There are two kinds of soil preparation methods in actual planting. One is cave form soil preparation in autumn, and the other is simple soil preparation to uncover sod in spring. Two types of soil preparation have no obvious difference on affecting trees growth and stand form, but they obviously affect IRR changes because of investment difference.

The cost of soil preparation in spring is lower than that of soil preparation in autumn, so IRR of soil preparation in spring is always little higher than that in autumn. The biggest IRR difference between the two preparation methods is 0.38%, and the smallest difference is 0.11% (Table 3).

Supposing four types of young growth tending methods, the first one is tending two times at the first year, two times at the second year, one time at the third year. The second one is tending two times at the first year, one time at the second year, one time at the third year. The third one is tending one time at the first year, one time at the second year, one time at the third year. The fourth one is tending one time at the first year, one time at the second year. After calculating IRR of four types of young growth tending method, we can find that the influence degree of tending intensity change on IRR is bigger than that of soil preparation. From the view of IRR change, the influence degree of tending intensity on IRR becomes less with the rotation prolonging. At 15 year the IRR increased by 1.16% with tending intensity reducing, and at 20, 25, 30, 35, 40 year, the IRR increased by 0.81%, 0.61%, 0.45%, 0.38%, and 0.35%, respectively (Table 3).

Table 2. IRR and NPV (Autumn soil preparation, discount rate is 10%)

Site grade	Density tree/hm^2	IRR of different age							NPV of different age						
		15	20	25	30	35	40	Ed*	15	20	25	30	35	40	Ed
I	2000	27.20	22.26	18.62	16.02	14.11	12.66	14.54	5335.27	5520.21	4583.05	3435.84	2339.14	1437.38	4082.83
	2500	26.35	21.29	17.94	15.59	13.78	12.40	13.95	5733.52	5455.20	4518.04	3370.83	2274.13	1372.37	4361.15
	3300	25.17	20.50	17.37	15.10	13.40	12.02	13.15	5600.38	5322.06	4384.90	3237.69	2140.99	1239.23	4361.15
	4400	23.74	19.51	16.62	14.51	12.86	11.62	12.12	5394.24	5115.92	4178.76	3031.55	1934.85	1033.09	6361.15
Extreme difference		3.46	2.75	2.00	1.51	1.25	1.04		398.25	404.29	404.29	404.29	404.29	404.29	
II	2000	21.97	20.37	17.18	14.78	12.87	11.35	10.62	2697.15	4038.66	3400.18	2441.11	1468.13	643.22	3395.44
	2500	22.72	19.61	16.74	14.53	12.74	11.28	11.44	3562.09	4039.58	3401.10	2442.03	1469.05	644.14	3395.44
	3300	22.00	18.89	16.23	14.12	12.45	11.00	11.00	3641.41	3940.62	3302.14	2343.07	1370.09	545.18	3395.44
	4400	20.62	17.92	15.50	13.55	11.92	10.63	9.99	3435.27	3734.48	3096.00	2136.93	1163.95	339.04	3395.44
Extreme difference		2.10	2.45	1.68	1.23	0.95	0.72		944.26	305.10	305.10	305.10	305.10	305.10	
Site extreme difference	2000	5.23	1.89	1.44	1.24	1.24	1.31		2638.12	1481.55	1182.87	994.73	871.01	794.16	
	2500	3.63	1.68	1.20	1.06	1.04	1.12		2171.43	1415.62	1116.94	928.80	805.08	728.23	
	3300	3.17	1.61	1.14	0.98	0.95	1.02		1958.97	1381.44	1082.76	894.62	770.90	694.05	
	4400	3.12	1.59	1.12	0.96	0.94	0.99		1958.97	1381.44	1082.76	894.62	770.90	694.05	

*: Ed- Extreme difference.

If we take present management fee as the lowest level, by changing management fee level, we can find that influence degree of management fee on IRR is very small, but it is bigger than that of young growth tending intensity and that of soil preparation method. When we raise management fee level by 60%, IRR decreases by 1.5%, 1.17%, 0.99%, 0.88%, 0.81%, and 0.72% at the rotation of 15, 20, 25, 30, 35, and 40 years, respectively (Table 3).

Table 3. Relationship between financial index and soil preparation methods, tending methods, management fee (Site grade II, 2 500 individuals per hectare, discount rate is10%)

Financial index	Age	Soil preparation type			Tending times					Management fee level				
		Spring soil preparation	Autumn soil preparation	Difference	2.2.1	2.1.1	1.1.1	1.1	Difference	100%	120%	140%	160%	Difference
IRR	15	23.10	22.72	0.38	22.72	23.08	23.57	23.86	1.16	22.72	22.20	21.70	21.22	1.50
	20	19.86	19.61	0.27	19.61	19.86	20.18	20.42	0.81	19.61	19.20	18.81	18.44	1.17
	25	16.92	16.74	0.18	16.74	16.92	17.16	17.35	0.61	16.74	16.40	16.05	15.75	0.99
	30	14.67	14.53	0.14	14.53	14.68	14.85	14.98	0.45	14.53	14.21	13.91	13.65	0.88
	35	12.85	12.74	0.11	12.74	12.86	12.98	13.12	0.38	12.74	12.47	12.19	11.93	0.81
	40	11.39	11.28	0.11	11.28	11.40	11.52	11.63	0.35	11.28	10.99	10.78	10.56	0.72
NPV	15	3602.46	3562.09	40.37	3562.09	3605.26	3652.74	3691.98	129.89	3536.09	3469.38	3376.66	3283.95	278.14
	20	4079.95	4039.58	40.37	4039.58	4082.75	4130.23	4169.47	129.89	4039.58	3935.79	3832.01	3728.24	311.31
	25	3441.47	3401.10	40.37	3401.10	3444.27	3492.75	3530.99	129.89	3401.10	3290.47	3179.82	3069.18	331.92
	30	2482.40	2442.03	40.37	2442.03	2485.20	2532.68	2571.92	129.89	2442.03	2327.14	2212.22	2097.32	344.71
	35	1509.42	1469.05	40.37	1469.05	1512.21	1559.69	1598.93	129.89	1469.05	1351.51	1233.95	1116.40	352.65
	40	684.51	644.14	40.37	644.14	687.30	734.78	774.02	129.89	644.14	524.95	405.76	286.55	357.59

NPV

On site class I, NPV reduce gradually with the rotation prolonging except that NPV is biggest at 20-year rotation and 2 000 individual per hectare. NPV of 15 years is the biggest, and the smallest in 40 years. On site class II, NPV of all densities is the biggest with 20-year rotation. NPV decreases gradually with the rotation prolonging. These also illustrate the higher the site class is, the more suitable for short rotation cultivation. The change principle of NPV with site class is just the same with IRR, but on site class II NPV of density 2 500 individuals per hectare is bigger than that of density 2 000 individuals per hectare at every age stage (Table 2).

Conclusion

During cultivation period of *Larix olgensis* pulp plantation the influence of the rotation on economic benefit is the biggest. In general, the shorter the rotation, the higher the economic benefit.

The influence of site class on economic benefit is also obvious, the higher the site class is, the higher the economic benefit is.

The influence of density on economic benefit is smaller

than that of the rotation and site class. The economic benefit of density 2 000 individuals per hectare on site class I is higher than that of density 2 500 individuals per hectare on site grade II. The influence of soil preparation and young growth tending method is small. On the base of assuring survival rate and conserving rate, the lesser fee used in soil preparation and young growth tending, the higher the economic benefit.

Management fee used in enterprise also has certain affection on economic benefit of *Larix olgensis* pulp plantation cultivation. Under the premise of assuring enterprise management makes progress, we should do our best to decrease management fee spending in order to increase economic benefit of *Larix olgensis* pulp plantation cultivation.

According to the measured data, influence of six measures on IRR could be determined in sequence as follows: rotation, site class, density, management fee level, young growth tending intensity, and soil preparation methods. Their contribution percentage and range are: rotation 9.99%-14.54%, site class 0.99%-5.23%, density 0.72%-3.46%, management fee level 0.72%-1.50%, young growth tending intensity 0.35%-1.16%, and soil preparation method 0.11%-0.38%.

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